



HAL
open science

Not all trade restrictions are created equally

Matthew T. Cole

► **To cite this version:**

Matthew T. Cole. Not all trade restrictions are created equally. *Review of World Economics*, 2011, 147 (3), pp.411-427. 10.1007/s10290-011-0090-1 . hal-00665003

HAL Id: hal-00665003

<https://hal.science/hal-00665003>

Submitted on 1 Feb 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Not All Trade Restrictions are Created Equally

Matthew T. Cole

January 18, 2011

Abstract There has been great focus in the recent trade theory literature on the introduction of firm heterogeneity into trade models. This introduction has highlighted the importance of the entry/exit decision of firms in response to changes in trade barriers. However, it is typical in many of these models to use iceberg transport costs as a general form of trade barriers that can be interchangeable with ad valorem tariffs. I show that this is not always an appropriate conclusion. Specifically, I illustrate that profit for an exporter is more elastic in response to tariffs than iceberg transport costs, which affects the entry/exit decision of firms. This has implications for welfare analysis and empirical specifications.

Keywords Intra-industry trade · Trade policy · Firm heterogeneity · Monopolistic competition

JEL classification: F10; F12; F13

I would like to thank Ron Davies, Bruce Blonigen, Peter Lambert, and seminar participants at the 2008 Midwest International Economics meeting (Urbana-Champaign, IL) and NUI Maynooth for helpful discussions and comments. This draft has benefited a great deal from comments by two anonymous referees. All remaining errors are my own.

UCD School of Economics, Newman Building (Room G215), University College Dublin, Belfield, Dublin 4, Ireland.
Tel.: +353 1-716-8320; Fax: +353 1-283-0068.
E-mail: colemat@gmail.com

1 Introduction

There has been great focus in the recent trade theory literature on the introduction of firm heterogeneity into trade models beginning with Jean (2002) and Melitz (2003). These models, among many others, have provided a significant advancement in the literature on intra-industry trade since its conception with Krugman (1979, 1980). This comes, in part, from highlighting the entry and exit mechanism of firms. In fact, Chaney (2008) illustrates how properly accounting for the extensive margin, in a model with firm heterogeneity, actually reverses the Krugman (1980) prediction that the elasticity of substitution magnifies the sensitivity of trade flows to trade barriers. Additionally, the entry and exit of firms has direct ramifications for the number of varieties in equilibrium. Since consumers in these models show a love of variety, this has important welfare implications; if more low productivity domestic firms exit in response to lower trade barriers than foreign exporting firms enter, the domestic country actually loses varieties from freer trade. This is indeed interesting since all the gains from trade in the “New Trade Theory” stemmed purely from gains in variety.¹

The more recent trade theory models still find gains from trade. However, the effect on product variety has less consensus. In Melitz (2003), the effect on the total mass of varieties in a particular country is left ambiguous. Baldwin and Forslid (2010) address this issue and find that decreased trade restrictions, in fact, have a counterintuitive anti-variety effect for the importing country. However, Melitz and Ottaviano (2008) find that decreased trade restrictions have a pro-variety effect. In all three models (as in most models dealing with such issues), trade restrictions are modeled as the standard iceberg transportation cost.² Although iceberg trade costs are equivalent to ad valorem tariffs in some settings, they are not equiva-

¹ Broda and Weinstein (2006) show that growth in product variety from US imports has been an important source of gains from trade.

² “Iceberg” transport costs are defined as a firm needing to ship more than one unit of good in order for one unit to arrive; the additional units “melt” away.

lent in the case of monopolistic competition. Therefore one cannot take the lessons learned from the existing literature and blindly apply them to changes in tariffs.³ A key contribution of this paper is to show iceberg transport costs affect firm profits and consequently the entry/exit decision differently than ad valorem tariffs in a monopolistic competition setting. At first glance, this may seem to be a minor point. But, in models of monopolistic competition, the entry/exit decision affects total product variety and the aggregate price index; both of which determine welfare. In some sense, this is not unlike the literature contrasting the effects of ad valorem with per-unit transport costs.⁴ However, the difference between iceberg transport costs and tariffs are more subtle because the two trade barriers are both ad valorem and the prices consumers pay are identical under each restriction. It is this subtlety that makes it so important to bring these differences to light.

To accomplish this, I provide a highly tractable model of heterogeneous firms that allows for asymmetric changes in three types of trade barriers; iceberg transport costs, ad valorem tariffs, and the additional fixed cost to become an exporter. Chaney (2008) uses a model with asymmetric iceberg transport costs and country sizes to investigate the effects of the elasticity of substitution on both the intensive and extensive margins of trade. He finds that the elasticity of substitution always dampens the impact of variable trade costs on trade flows. In particular, the decreased sensitivity of the extensive margin outweighs the increased sensitivity of the intensive margin. However, variable trade costs are modeled only as iceberg transport costs and not ad valorem tariffs. Thus, in this regard, my paper complements Chaney (2008) as it illustrates how the entry/exit decision of a firm is different depending on whether one models trade barriers as iceberg transport costs or ad valorem tar-

³ Similarly, it may not be appropriate to simply “waste” tariff revenue in order to model iceberg transport costs as Jørgensen and Schröder (2008) does.

⁴ See, for example, Irarrazabal et al. (2010) who show that welfare gains from reducing per-unit frictions are higher than that of reducing iceberg frictions.

iffs. In a general equilibrium model, this difference will affect the extensive margin directly and the intensive margin indirectly.⁵

In order to provide the most tractable baseline model, I make various key assumptions that greatly ease the analysis of a situation with heterogeneous firms and endogenous entry. First, I assume firms are heterogeneous across fixed cost. Though the majority of the recent models assume firms are heterogeneous across marginal cost, there is a growing literature that assumes firms differ across fixed cost, e.g. Schmitt and Yu (2001), Jørgensen and Schröder (2006, 2008), and Davies and Eckel (2007).⁶ Jørgensen and Schröder (2008) provide a very nice motivation for the use of fixed cost heterogeneity. For instance, they point out that fixed cost heterogeneity is more appropriate with so-called “original brand name manufacturers” that differ in the power of their brand name – a result of marketing and other fixed cost activities. Arkolakis (2008) also incorporates marketing into a model with heterogeneous firms. Though firms can differ in expenditures on marketing, the main source of heterogeneity is from marginal cost in this model. This coincides well with recent empirical results that suggest there is heterogeneity in fixed as well as marginal cost. For instance, Cole, Elliott, and Virakul (2009) find that sunk costs (which are identical to fixed costs in my static model) and firm characteristics are important factors in explaining Thai manufacturing firm’s decision to export.⁷ I have chosen to use fixed cost heterogeneity for three reasons: using marginal cost heterogeneity will not change the qualitative results; marginal cost heterogeneity will complicate the comparative statics significantly; and there is evidence that firms do differ across fixed costs.⁸

⁵ See Cole (2010) for an explicit description of how my paper complements Chaney (2008).

⁶ A key difference between Jørgensen and Schröder (2006, 2008) and my model is that all firms, purely domestic and those who export, are heterogeneous across fixed cost, where Jørgensen and Schröder (2006, 2008) only allow the fixed cost to *export* to differ.

⁷ See also Eaton et al. (2008) who use a Melitz-type model calibrated to a French data set, and Lawless and Whelan (2008) who explain trade flows for Irish owned firms.

⁸ The use of fixed cost heterogeneity results in all firms of the same “type” (either pure domestic or exporting) to charge the same price. This obviously affects firm demand and profits which in turn affects the

Second, I assume the representative consumer has Dixit–Stiglitz preferences embedded in a quasi-linear utility function. The cost of this assumption is that the income elasticity of demand for the heterogeneous good is zero. Despite the cost, this assumption is not entirely uncommon in the literature. Chor (2009) uses a similar technique to investigate the merits of subsidizing foreign direct investment (FDI) in a model with heterogeneous firms.⁹ Moreover, some models use more general utility functions, but then make other simplifying assumptions that mitigate income effects. Demidova and Rodríguez-Clare (2009) utilize a small country assumption to eliminate any income feedback effects. Similarly, Chaney (2008) makes a small/remote country assumption to ensure changes in transport and fixed costs have no significant impact on the general equilibrium.¹⁰ In this paper, quasi-linear preferences prove useful beyond the simplifications they provide. My goal is to compare the differences between iceberg transport costs and ad valorem tariffs. Tariffs generate income and transport costs are often assumed to be lost. Thus, tariffs would create an income effect whereas iceberg transport costs would not, clouding the difference I focus on. Alternatively, I could model a transport sector that generates income, but I would need to take up a stance on which country the transport sector resides in as the income would affect demand.¹¹

Finally, in addition to the typical barriers to trade (tariffs and transport costs), I consider the effect of “foreign beachhead costs”, that is, those fixed costs necessary to switch to engage in exporting.¹² This is often a minor consideration, but with the rapid technological growth and service industries being created to facilitate business operations, these beachhead costs are becoming increasingly important. Friedman (2007:173) explains, “...UPS also has

entry and exit decision. However, this does not eliminate the differences between iceberg transport costs and ad valorem tariffs as trade barriers.

⁹ See also Becker (2009).

¹⁰ Chaney (2008) points out that relaxing this assumption would reinforce his results.

¹¹ It should be noted that income does change in response to changes in trade barriers and this income change affects welfare. However, it will all be through changes in consumption/production of the numeraire and not affect the heterogeneous goods sector.

¹² The term ‘beachhead’ costs was coined by Baldwin (1988).

a financing arm – UPS Capital – that will put up the money for the transformation of your supply chain, particularly if you are a small business and don't have the capital...UPS is creating enabling platforms for anyone to take his or her business global or vastly improve the efficiency of his or her global supply chain". This has direct implications for these particular beachhead costs and needs to be considered in conjunction with investigating changes in other trade restrictions, as they may have conflicting results.

The paper proceeds as follows. Section 2 sets up the model and characterizes the equilibrium. Section 3 analyzes the results including a discussion of the results under alternative modeling assumptions including marginal cost heterogeneity. Section 4 concludes.

2 The Model

There are two countries labeled k and j . Country k (j) is endowed with \bar{L}_k (\bar{L}_j) units of labor which is the sole factor of production. Without loss of generality, let $\bar{L}_k \geq \bar{L}_j$. There are two sectors. Sector 1 is the numeraire and consists of a homogeneous good (y) that is produced under constant returns to scale, freely traded, and sold in a perfectly competitive market. Sector 2 consists of a continuum of differentiated goods, each variety of which is indexed by i . As is standard in the Melitz model, this is produced under increasing returns to scale in a monopolistically competitive market with free entry. Unlike sector 1, this market may face both transportation costs and tariff barriers. With the exception of different labor endowments and (potentially) tariff rates, countries are identical. Therefore, analyzing the situation for country k informs us of the analogous situation for country j , and I will refer to country k as the domestic country to ease discussion.

2.1 Sector 1

The price of good Y is normalized to 1 in each market. Assuming that one unit of labor is needed for production, this will normalize the wage in each country to unity. Finally, I assume that in equilibrium a positive amount of good Y is produced in each country.

2.2 Consumers

The representative consumer in country k has quasi-linear preferences with an embedded Dixit–Stiglitz utility function which displays love for variety over the heterogeneous good;

$$U_k = \mu \ln(X_k) + Y_k, \quad X_k = \left(\int_0^{N_k} x_k(i)^\alpha di \right)^{\frac{1}{\alpha}}, \quad \mu > 0 \quad (1)$$

where $\varepsilon = 1/(1 - \alpha) > 1$ is the elasticity of substitution, N_k is the total mass of varieties in country k , Y_k denotes aggregate consumption of the numeraire, and X_k can be interpreted as the amount of a composite good comprised of the different varieties of the heterogeneous good $x_k(i)$. Quasi-linear utility will isolate the decision whether to become an exporter or not without any income feedback effects; providing a model that allows for asymmetric changes in trade restrictions to be easily analyzed. Moreover, this specification allows me to compare the differences between an ad valorem tariff and iceberg trade costs on productivity and variety without having to account for the income effects of the tariff or the “wasteful” costs of iceberg transport costs. Finally, I assume that income in each country is sufficiently large that both y and x goods are consumed.

Consumers maximize utility subject to their budget constraint:

$$\int_0^{N_k} p_k^c(i) x_k(i) di + Y_k \leq I_k \quad (2)$$

where $p_k^c(i)$ is the price of variety i paid by consumers and I_k is aggregate income in country k .¹³ The solution to this problem yields a demand function for the heterogeneous good of variety i in country k :

$$x_k(i) = \frac{p_k^c(i)^{-\varepsilon} \mu}{\int_0^{N_k} p_k^c(i)^{1-\varepsilon} di}. \quad (3)$$

Since preferences are identical across both countries, it follows that the total expenditure on the heterogeneous good is equal to μ in both foreign and domestic markets.

2.3 Heterogeneous Firms

There are a continuum of firms, each of which holds a unique position on an index, where each point i represents a unique variety and productivity level.¹⁴ Armed with this index the firm decides whether to serve the domestic market and/or the overseas market. To serve a given market, the firm must incur a fixed cost. These costs are referred to as ‘beachhead’ costs and can be interpreted as forming a distribution and servicing network. To serve its domestic market, a firm with index i must hire $f(i)$ units of labor (making the fixed cost of serving this market $f(i)$). If a firm chooses to serve the foreign market, it can do so through exports and pay an *extra* $\gamma f(i)$. I assume that $\gamma > 1$; $f'(i) > 0$ and $f''(i) \geq 0$, i.e. the mapping from the index to the labor required for beachhead costs is increasing and convex in the index.¹⁵ Thus, firms requiring fewer workers to cover beachhead costs have a lower

¹³ Note that if tariffs are set to zero or the firm is domestic the prices, $p_k(i) = p_k^c(i)$, are equivalent. Furthermore, recall that under perfect competition, the price of y is equal to one.

¹⁴ One interpretation of the model is that firms are owned by entrepreneurs and that firm profits accrue to these entrepreneurs. In my representative agent setting, these profits would simply enter national income in the same way that wages do, therefore I discuss the model in terms of firms to avoid needless jargon. This interpretation is similar to that of Yu (2002). Additionally, it is common in heterogeneous firm models to have entrepreneurs draw from a distribution of productivities (often at a cost). The advantage to that approach is that it permits multiple varieties to have the same productivity. The cost, however, is one of added complexity and additional assumptions since modelers are often forced to parameterize this distribution (the Pareto distribution is a common choice). Here, my assumption of unique variety/productivity combinations aids greatly in the presentation of my results in the simplest, most tractable fashion.

¹⁵ The assumption that $\gamma > 1$ is fairly standard (e.g. Melitz (2003)) and important. It is rarely seen that a firm (particularly not a multinational) that sells abroad but not at home and as long as expenditure on the

index i . These fixed cost differences are the source of firm heterogeneity. A firm, therefore, faces the menu of fixed costs (measured in units of labor) illustrated by Table 1:

Table 1 Fixed Cost Menu

Firm Type	Fixed Cost
domestic only	$f(i)$
domestic and exporter	$(1 + \gamma)f(i)$

Goods that are exported from country k to country j are subject to melting-iceberg transport costs, $\sigma = 1 + s \geq 1$, where a firm must ship σ units in order for one unit to arrive at its destination. I assume that transport costs are symmetric and thus omit country subscripts.¹⁶ I do not investigate the effect of a per-unit transport cost; since marginal costs are identical for all exporting firms, this would have the same effect as iceberg transport costs. Additionally, an exporting firm from country k is subject to an ad valorem tariff τ_j , where I define $t_j \equiv 1 + \tau_j$. Furthermore, I assume that a government is unable to distinguish a particular firm's type, so any tariff is an across-the-board tariff applied to all exporters. Note that tariffs can differ across countries.

The decision to become a firm and which market(s) to service depends on the associated profit for each type. Recall that the numeraire yields wages equal to one in both countries, thus the operating profits from serving the domestic market are

$$\pi_D^k(i) = p_k(i)q_k(i) - q_k(i) - f(i). \quad (4)$$

heterogeneous good are not *too* different, this ensures that will never happen. Moreover, it does so by allowing profits in both countries to be additively separable, which is quite attractive. Relaxing this assumption, but restricting the firm to sell at home before exporting would only complicate the model without changing the qualitative results.

¹⁶ This assumption is only done for notational ease. In order to investigate asymmetric changes in transport costs, one only needs add a country subscript to σ .

Given the nature of monopolistic competition, the price will be a constant mark-up over marginal cost and be equal to $\frac{1}{\alpha}$. From market clearing, set $q_k(i) = x_k(i)$, and the firm has the following profit function for supplying to the domestic market only:

$$\pi_D^k(i) = B_k - f(i) \quad (5)$$

where

$$B_k = \left(\frac{1}{\varepsilon \alpha^{1-\varepsilon}} \right) \frac{\mu}{\mathcal{P}_k^{1-\varepsilon}}$$

and $\mathcal{P}_k = \left(\int_0^{N_k} p_k^c(i)^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}}$ is the aggregate price index of the heterogeneous good.

The decision to become an exporter stems purely from the *additional* profits from serving the foreign market.¹⁷ The main contribution of this paper is to illustrate that there is an important distinction between modeling trade restrictions as iceberg transport costs or ad valorem tariffs. Consequently, I will explicitly derive the additional profit function from exports for the firm in country k exporting to country j . This function is:

$$\pi_X^k(i) = t_j p_j(i) x_j(i) - \tau_j p_j(i) x_j(i) - \sigma x_j(i) - \gamma f(i). \quad (6)$$

It can easily be seen by $t_j p_j(i) x_j(i) - \tau_j p_j(i) x_j(i) = p_j(i) x_j(i)$, that imposing a tariff on the firm is analogous to imposing it on the consumer. Recalling that $p_j^c(i)$ is the price consumers pay, the demand for variety i is

$$x_j(i) = \frac{p_j^c(i)^{-\varepsilon} \mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon} di} = \frac{[t_j p_j(i)]^{-\varepsilon} \mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon} di}. \quad (7)$$

¹⁷ Since preferences are identical across both countries, it follows that the total expenditure on the heterogeneous good is equal to μ in both markets. Furthermore, recall that technologies and the mass of entrepreneurs are also identical across countries. This, along with $\gamma > 1$, is sufficient to ensure that a firm which exports will always serve the domestic market.

Thus (6) can be written as

$$\pi_X^k(i) = [p_j(i) - \sigma] \frac{[t_j p_j(i)]^{-\varepsilon} \mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon} di} - \gamma f(i) \quad (8)$$

Note that the presence of a tariff is just a monotonic transformation of the profit function, so the firm's optimal price setting rule is unaffected by the tariff (it is still a constant markup over marginal cost). However, the price paid by the consumer, p^c , is affected. Therefore, the exporting firm's optimal price is

$$p_j(i) = -\frac{\varepsilon \sigma}{1 - \varepsilon} = \frac{\sigma}{\alpha} \quad (9)$$

and the price consumers pay for exported variety (imported from their perspective) is

$$p_j^c(i) = \frac{t_j \sigma}{\alpha}. \quad (10)$$

Thus, regardless of whether one chooses to model trade restrictions as iceberg transport costs, ad valorem tariffs, or some more general term encompassing them both, $\zeta = t\sigma$, the effect on the price consumers pay is the same – the restriction is completely passed through onto them. *However*, the effects on firm profits are, in fact, different and this is important when dealing with a general equilibrium model and firm entry. To see this, insert the price, (9), into the firm profit function (8)

$$\pi_X^k(i) = \underbrace{\left[\frac{\sigma}{\alpha} - \sigma \right]}_{\text{markup}} \left(\frac{t_j \sigma}{\alpha} \right)^{-\varepsilon} \frac{\mu}{\mathcal{D}_j^{1-\varepsilon}} - \gamma f(i). \quad (11)$$

The underbraced term is the key here. Due to the monopolistic nature of the model, firms charge a markup over marginal cost and transport costs are included in marginal cost.¹⁸ Recall $\sigma = 1 + s$. If a firm ships one unit, it loses s units in transport, but gains $\frac{s}{\alpha}$ from its ability to charge a price higher than marginal cost, for a net gain (excluding demand effects) of $\frac{s}{\alpha\epsilon} > 0$. Conversely, a tariff results only in decreased demand, which as seen by (10) is identical to that of iceberg transport costs. Thus, not only are profits higher with iceberg transport costs compared to an identical ad valorem tariff, but the sensitivity of profits to changes in these two different forms of trade restrictions differs as well; i.e. the variable profit will be more elastic with respect to tariffs than iceberg transport costs.¹⁹ Essentially, through monopolistic power, the firm is able to recoup a portion of its losses in transport; whereas tariff revenue is completely captured by the domestic government. The markup over marginal cost drives a wedge between the effect of iceberg transport costs and an ad valorem tariff.

The effect of trade restrictions on product variety is an important welfare consideration and is determined by the extent domestic varieties enter to replace imported foreign varieties. Since the choice of trade restrictions affects the variable profit elasticity and consequently the foreign firm's decision to enter or exit, this has implications with regard to product variety. For notational ease, I will write profits from exports as:

$$\pi_X^k(i) = t_j^{-\epsilon} \sigma^{1-\epsilon} B_j - \gamma f(i). \quad (12)$$

Again, note the different exponents on tariffs (t_j) and transport costs (σ), a difference at the heart of the differing variety effects.

¹⁸ Note that, in perfect competition, price equals marginal cost and the standard result of iceberg costs having the same effect as an ad valorem tariff still holds.

¹⁹ This will be shown later.

2.3.1 Relaxing Modeling Assumptions

In this section, I briefly describe the effects of two specific assumptions on the results' generality. To begin, suppose firms were additionally heterogeneous across marginal costs, $a(i)$. This means that firms will charge a different price; specifically $\frac{t_j \sigma a(i)}{\alpha}$ for an exporter.²⁰ Additionally, let $M_j(\mathbf{p}_j^c, I_j(\cdot))$ be the expenditure on the heterogeneous good in country j , which is a function of the vector of prices and income. Therefore, an exporting firm is faced with the following general profit function:

$$\pi_X^k(i) = \underbrace{\left[t_j^{-\varepsilon} \sigma^{1-\varepsilon} \right]}_{\varepsilon} \frac{a(i)^{1-\varepsilon} M_j}{\left[\int_0^{i_{jD}} a(i)^{1-\varepsilon} di + \int_0^{i_{kX}} (t_j \sigma a(i))^{1-\varepsilon} di \right]} - \gamma f(i) \quad (13)$$

i.e. the B_j term becomes more complex.

For a baseline model, I assume that $a(i) = 1$ for all i , and $M_j = \mu$. It can be seen that allowing marginal cost to differ across firms will have an affect on the results. However, since the t_j is raised to a different exponent than σ in the underbraced term, differences still arise for different trade barriers. Furthermore, using a different utility function will obviously affect $M_j(\mathbf{p}_j^c, I_j(\cdot))$.²¹ In particular, tariffs generate income where iceberg transport costs are generally assumed to be wasted. There are two points to be made with regard to this: One, in order for tariffs to have the same affect on exporting firm profits as iceberg transport costs, the utility function would have to result in $M_j(\mathbf{p}_j^c, I_j(t_j, \cdot)) \equiv t_j M_j(\mathbf{p}_j^c, I_j(\cdot))$, which is more restrictive than assuming quasi-linear preferences; and two, as mentioned in the introduction, there *is* a transportation sector that *does* generate income. To be completely rigorous, I would need to model this sector. However, it would seem to be a very special case, in which tariffs and transport costs affect income in such a way to offset the differences highlighted

²⁰ Recall equation (10).

²¹ Note though, that t_j and σ affect \mathbf{p}_j^c in the exact same way, as shown by equation (10).

by the underbraced term in equation (13). Therefore, the result that ad valorem tariffs affect exporting profits differently than iceberg transport costs is not driven by my simple baseline model.

2.4 Equilibrium

Firms will enter each market as long as there are positive profits, that is, until equations (5) and (12) are driven to zero. Thus, define the cut-off firms as the firms that draw the values in the index (i) that solves the following equalities:

$$B_k = f(i_{kD}) \quad (14)$$

$$\frac{B_j}{\gamma_j^\varepsilon \sigma^{\varepsilon-1}} = f(i_{kX}) \quad (15)$$

$$B_j = f(i_{jD}) \quad (16)$$

$$\frac{B_k}{\gamma_k^\varepsilon \sigma^{\varepsilon-1}} = f(i_{jX}). \quad (17)$$

The indices i_{kD} and i_{jD} represent the firms that are indifferent between producing the heterogeneous good and not producing at all in country k and j respectively. The indices i_{kX} and i_{jX} represent the firms that are indifferent between serving both the domestic and foreign markets and serving only the domestic market. Furthermore, the terms on the left-hand side of the equalities represent the variable profit for a particular firm and are functions of the total mass of firms (domestic and foreign).²²

Figure 1 illustrates the profits, with zero variable trade costs, of firms in country k including those who export and those who only sell domestically.²³ It can be seen that the greater the index i , the greater the fixed cost to enter a market, and thus the lower the profits.

²² Note that since τ and σ enter B identically, it can be seen by equations (15) and (17) that, ceteris paribus, iceberg transport costs and ad valorem tariffs will lead to different firm cutoff values.

²³ For numerical simulations, I assume that the function $f(i)$ is linear.

The intersection with the horizontal axis represents the index in which profits are zero for operating in that particular market. Note that the line representing export profits defines the profits from exporting in addition to serving the domestic market. In other words, firms with an index $i \in [0, i_{kX}]$ make profits from exporting *and* serving the domestic market, and firms with an index $i \in (i_{kX}, i_{kD}]$ make profits from only serving the domestic market. Firms with an index $i > i_{kD}$ do not produce.

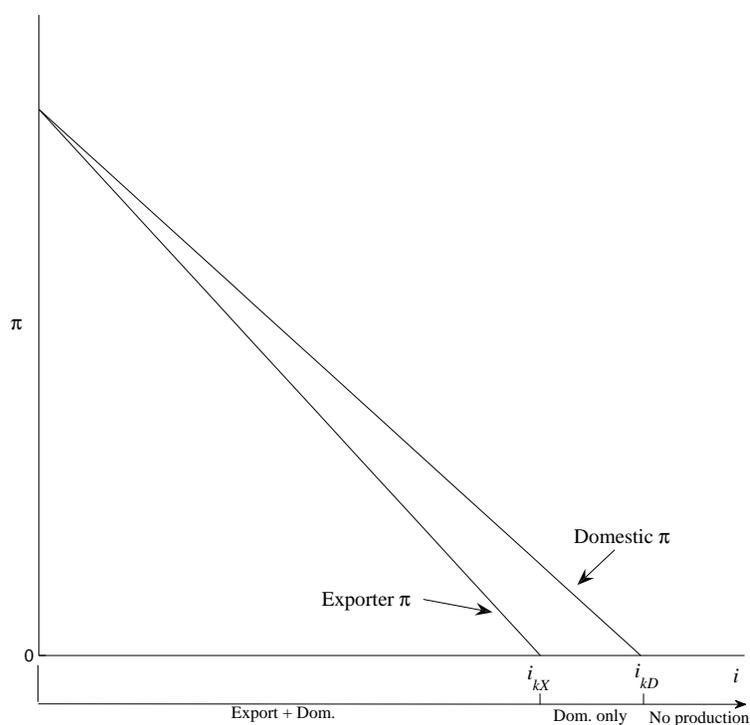


Fig. 1 Profits from production in country k with free trade

After careful inspection of the equilibrium conditions, it can be seen that there are, in fact, two systems of two equations and two unknowns: equations (14) and (17) and equations (15) and (16).²⁴ Moreover, due to the symmetry it is sufficient to only focus on one country.

²⁴ This nice simplification stems from the utility specification used.

I will focus on the output market in country k , and thus equations (14) and (17). For future use, it will be helpful to rewrite the equilibrium conditions, (14) and (17), in the following manner:

$$f(i_{kD}) = \frac{\mu}{\varepsilon(i_{kD} + (t_k \sigma)^{1-\varepsilon} i_{jX})} \quad (18)$$

$$f(i_{kD}) = \gamma t_k^\varepsilon \sigma^{\varepsilon-1} f(i_{jX}). \quad (19)$$

3 Changes in Equilibrium

Although, I cannot explicitly solve for the cutoff values without assuming a functional form of the fixed cost mapping $f(i)$, I am still able to characterize the comparative statics. Totally differentiating this system of equations (18) and (19) yields the following comparative statics:

$$\frac{\partial i_{jX}}{\partial t_k} = -\frac{1}{t_k \psi} \left[\varepsilon f(i_{kD}) [1 + \delta(i_{kD})] + \frac{i_{jX} f'(i_{kD})}{(t_k \sigma)^{\varepsilon-1}} \right] < 0 \quad (20)$$

$$\frac{\partial i_{jX}}{\partial \sigma} = \frac{(1-\varepsilon)f(i_{kD})}{\sigma \psi} [1 + \delta(i_{kD})] < 0 \quad (21)$$

$$\frac{\partial i_{jX}}{\partial \gamma} = -\frac{f'(i_{kD})}{f(i_{kD}) \psi \gamma} \left[\frac{\mu}{\varepsilon} + \frac{f(i_{kD})^2}{f'(i_{kD})} \right] < 0 \quad (22)$$

$$\frac{\partial i_{kD}}{\partial t_k} = \frac{\varepsilon \gamma f(i_{jX})}{\psi} [1 + \alpha \delta(i_{jX})] > 0 \quad (23)$$

$$\frac{\partial i_{kD}}{\partial \sigma} = \frac{(\varepsilon-1) \gamma t_k f(i_{jX})}{\sigma \psi} [1 + \delta(i_{jX})] > 0 \quad (24)$$

$$\frac{\partial i_{kD}}{\partial \gamma} = \frac{t_k f(i_{jX})}{\psi} > 0 \quad (25)$$

where

$$\psi \equiv \frac{f'(i_{kD})}{f(i_{kD})} \left[\frac{f'(i_{jX})}{f(i_{jX})} \left(\frac{\mu}{\varepsilon} + \frac{f(i_{kD})^2}{f'(i_{kD})} \right) + \gamma t_k f(i_{jX}) \right], \text{ and}$$

$$\delta(z) = \frac{z f'(z)}{f(z)} > 0.$$

The term $\delta(z)$ represents the elasticity of fixed costs with respect to the index i , evaluated at z . Equations (20) through (22) represent the effect of changes in trade restrictions (either through a tariff, transport cost, or foreign beachhead cost) on the cutoff firm serving the foreign market. It follows that increases in trade restrictions decrease this cutoff, or in other words the mass of exporting firms has decreased. By decreasing the mass of exporting firms and the foreign firms still producing now charging a higher price relative to domestic producers, there is less competition in the domestic market. This decreased competition makes being a domestic firm more profitable, thereby increasing the mass of domestic firms – illustrated by equations (23) through (25). The fact that increased trade restrictions, in general, have these results is not surprising. What is important is that different trade restrictions correspond to different magnitudes in firm cutoff changes.

It is not sufficient to simply show that the magnitudes of the comparative statics are different in order to show that there is a meaningful difference between iceberg transport costs and ad valorem tariffs. If there is a mapping between t_k and σ that equates the comparative statics, then we simply have a monotonic transformation. In fact, there does exist a (t_k, σ) pair that equates the comparative statics (20) with (21) and (23) with (24). However, this pair is not identical for both equalities. Note the following:

$$\frac{\partial i_{jX}}{\partial t_k} = \frac{\partial i_{jX}}{\partial \sigma} \Leftrightarrow \frac{\alpha t_k}{\sigma} = 1 + \frac{(t_k \sigma)^{1-\varepsilon} i_{jX} f'(i_{kD})}{\varepsilon f(i_{kD}) [1 + \delta(i_{kD})]} > 1 \quad (26)$$

$$\frac{\partial i_{kD}}{\partial t_k} = \frac{\partial i_{kD}}{\partial \sigma} \Leftrightarrow \frac{\alpha t_k}{\sigma} = \frac{1 + \alpha \delta(i_{jX})}{1 + \delta(i_{jX})} < 1 \quad (27)$$

As can be seen, the (t_k, σ) pair that equates (20) with (21) is not the same pair that equates (23) with (24). This reinforces the fact that iceberg transport costs are not isomorphic to ad valorem tariffs. I illustrate this in more detail throughout the following sections.

3.1 Variety Effect

As just shown, different trade barriers affect the entry and exit decision by firms in different ways. This is important for two main reasons; the effect on total variety is part of welfare and if two or more barriers are changing at the same time, it is critical to understand these differences to know whether these changes will amplify or negate each other. Therefore, I now investigate how each trade barrier affects the equilibrium mass of varieties. The corresponding effects on the mass of varieties in country k are as follows:²⁵

$$\frac{\partial N_k}{\partial t_k} = \frac{\varepsilon \gamma f(i_{jX})}{\psi} \left\{ 1 + \alpha \delta(i_{jX}) - (t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] - \frac{i_{jX}}{\varepsilon i_{kD}} \delta(i_{kD}) \right\} \quad (28)$$

$$\frac{\partial N_k}{\partial \sigma} = \frac{(\varepsilon - 1) \gamma t_k f(i_{jX})}{\sigma \psi} \left\{ [1 + \delta(i_{jX})] - (t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] \right\} \quad (29)$$

$$\frac{\partial N_k}{\partial \gamma} = \frac{1}{\psi \gamma} \left[\left(\frac{1}{(t_k \sigma)^{\varepsilon-1}} - 1 \right) f(i_{kD}) - \frac{f'(i_{kD})}{f(i_{kD})} \frac{\mu}{\varepsilon} \right] < 0 \quad (30)$$

It can be seen from equations (28) and (29) that the effect of tariffs and iceberg transport costs have an ambiguous effect on equilibrium total variety. The following proposition pins down the condition that ensures a pro-variety effect associated with decreases in iceberg transport costs.²⁶

Proposition 1 *There is a pro-variety effect associated with decreases in iceberg transport costs if and only if*

$$\frac{1}{(t_k \sigma)^{\varepsilon-1}} < \frac{1 + \delta(i_{kD})}{1 + \delta(i_{jX})}.$$

Proof Proof is by direct calculation.

This is a sufficient and necessary condition. A more restrictive condition for a pro-variety effect, although one that is perhaps more intuitive, is if the elasticity of $f(i)$ with respect to

²⁵ Note that $N_k = i_{kD} + i_{jX}$.

²⁶ Note that this is the case when $\partial N_k / \partial \sigma < 0$.

the index is nondecreasing in i . Examples would include both linear, exponential, and power functions of i .

It is difficult to compare the magnitudes of the variety effects from changes in iceberg transport costs and ad valorem tariffs because these magnitudes depend on the actual values of t_k and σ .²⁷ However, I can comment on the direction of these variety effects.

Corollary 1 *If $\frac{\partial N_k}{\partial \sigma} \leq 0$ then $\frac{\partial N_k}{\partial t_k} < 0$.*

Proof Let $\frac{\partial N_k}{\partial \sigma} = 0$, then

$$(t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] = 1 + \delta(i_{jX}).$$

Plugging this into (28) yields:

$$\begin{aligned} \frac{\partial N_k}{\partial t_k} &= \frac{\varepsilon \gamma f(i_{jX})}{\psi} \left\{ 1 + \alpha \delta(i_{jX}) - 1 - \delta(i_{jX}) - \frac{i_{jX}}{\varepsilon i_{kD}} \delta(i_{kD}) \right\} \\ &= \frac{-\gamma f(i_{jX})}{\psi} \left\{ \delta(i_{jX}) + \frac{i_{jX}}{i_{kD}} \delta(i_{kD}) \right\} < 0. \end{aligned}$$

It is straightforward that $\frac{\partial N_k}{\partial \sigma} < 0 \Rightarrow \frac{\partial N_k}{\partial t_k} < 0$.

It is obvious that the contrapositive to Corollary 1 is also true, that is $\frac{\partial N_k}{\partial t_k} \geq 0 \Rightarrow \frac{\partial N_k}{\partial \sigma} > 0$. The fact that trade restrictions can have an ambiguous effect on total product variety in a country is not surprising or new. What is surprising and new is that it is possible for there to be an anti-variety effect associated with lower transport costs while there also being a pro-variety effect associated with lower tariffs. Thus, under certain specifications a reduction in both trade barriers could lead to no change in total product variety. Again, these differences

²⁷ For purposes of comparison, one logical choice would be to evaluate the comparative statics when the trade restrictions are equal. Let $\sigma = t_k = \rho \geq 1$, then

$$\left. \frac{\partial N_k}{\partial t_k} \right|_{\sigma=t_k=\rho} = \left. \frac{\partial N_k}{\partial \sigma} \right|_{\sigma=t_k=\rho} + \left(\frac{\gamma}{\rho} \right) \left. \frac{\partial N_k}{\partial \gamma} \right|_{\sigma=t_k=\rho}.$$

are driven by how iceberg transport costs affect profit differently than an ad valorem tariff.

Changes in a firm's variable profit ($v\pi$) are the reason for entry and exit and the variable profit is more elastic with respect to tariffs than iceberg transport costs:

$$\frac{t_k}{v\pi} \frac{\partial v\pi}{\partial t_k} - \frac{\sigma}{v\pi} \frac{\partial v\pi}{\partial \sigma} = \frac{-f'(i_{jX}) [f'(i_{kD})\mu + \varepsilon f(i_{kD})^2]}{f'(i_{jX}) [f'(i_{kD})\mu + \varepsilon f(i_{kD})^2] + \varepsilon \gamma t_k f(i_{jX})^2 f'(i_{kD})} < 0.$$

This, in turn, affects the elasticity of the firm cutoffs – the cutoffs for an exporting and a purely domestic firm are more elastic in response to a change in an ad valorem tariff than iceberg transport costs. Turning now to the elasticity of total variety, N_k , which I define as ρ_{t_k} and ρ_σ for tariffs and transport cost respectively:

$$\rho_{t_k} = \frac{\varepsilon \gamma t_k f(i_{jX})}{N_k \psi} \left\{ 1 + \alpha \delta(i_{jX}) - (t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] - \frac{i_{jX}}{\varepsilon i_{kD}} \delta(i_{kD}) \right\}$$

$$\rho_\sigma = \frac{(\varepsilon - 1) \gamma t_k f(i_{jX})}{N_k \psi} \left\{ 1 + \delta(i_{jX}) - (t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] \right\}.$$

Comparing the two elasticities yields:

$$\rho_{t_k} - \rho_\sigma = \frac{t_k \gamma f(i_{jX})}{N_k \psi} \left\{ 1 - (t_k \sigma)^{\varepsilon-1} [1 + \delta(i_{kD})] - \frac{i_{jX}}{i_{kD}} \delta(i_{kD}) \right\} < 0.$$

One has to be careful in interpreting this result given the results of Corollary 1. If there is a pro-variety effect associated with a decrease in iceberg transport costs, then the total product variety is *more* elastic (but is negative) with respect to tariffs.²⁸ If there is an anti-variety effect associated with a decrease in ad valorem tariffs, then the total product variety is *less* elastic (but is positive) with respect to tariffs.²⁹ Finally, there are scenarios in which

²⁸ Recall, from Corollary 1, that if $\rho_\sigma \leq 0 \Rightarrow \rho_{t_k} < 0$. Thus, in this case, if $(\rho_{t_k} - \rho_\sigma) < 0$ then $|\rho_{t_k}| > |\rho_\sigma|$.

²⁹ Again, from Corollary 1, it follows that if $\rho_{t_k} \geq 0 \Rightarrow \rho_\sigma > 0$. Thus, in this case, if $(\rho_{t_k} - \rho_\sigma) < 0$ then $|\rho_\sigma| > |\rho_{t_k}|$.

the two trade barriers have opposite effects on variety resulting in ambiguity as to the relative elasticities.

3.2 Welfare Effect

Though the number (mass) of varieties is a significant part of welfare, it is not the only part; price changes also affect welfare. In this section, I analyze how modeling trade barriers as iceberg transport costs affects welfare (through both variety and price changes) differently than by using an ad valorem tariff. The indirect utility of the representative consumer, and my measure of national welfare, is

$$V_k = \mu \ln(X_k) + I_k - \mu. \quad (31)$$

Income is equal to labor income plus profits from domestically owned firms (for purposes of comparison, I will omit tariff revenue and a transport sector as sources of income):

$$I_k = L_k + \int_0^{i_{kX}} \pi_X^k(i) di + \int_0^{i_{kD}} \pi_D^k(i) di.$$

There are many potential ways to compare the different effects on welfare from changes in the different trade barriers. In order to be as succinct and clear as possible, I make a few further assumptions. As mentioned, I omit the different avenues of income from trade barriers; i.e. through tariffs or a transport sector. Furthermore, although this model can easily analyze asymmetric changes in trade barriers, I will focus on symmetric changes in identical tariff levels ($t_k = t_j = t$). Note that these assumptions, along with quasi-linear utility, result in a completely symmetric equilibrium. Thus, for brevity, I will drop country subscripts.

Differentiating national welfare (31) of country k with respect to the tariff and iceberg transport costs yields:³⁰

$$\frac{\partial V}{\partial t} = \left[\frac{(C_D + \sigma C_X) - \mu}{\mathcal{P}} \right] \frac{\partial \mathcal{P}}{\partial t} - \frac{\sigma C_X}{t\alpha} < 0, \quad (32)$$

$$\frac{\partial V}{\partial \sigma} = \left[\frac{(C_D + \sigma C_X) - \mu}{\mathcal{P}} \right] \frac{\partial \mathcal{P}}{\partial \sigma} - C_X < 0, \quad (33)$$

where

$$\begin{aligned} \frac{\partial \mathcal{P}}{\partial t} &= \left[\frac{\mathcal{P}^\varepsilon}{\alpha^{1-\varepsilon}(1-\varepsilon)} \right] \left[\frac{\partial i_D}{\partial t} + (1-\varepsilon) \frac{(\sigma t)^{1-\varepsilon}}{t} i_X + (\sigma t)^{1-\varepsilon} \frac{\partial i_X}{\partial t} \right] > 0, \text{ and} \\ \frac{\partial \mathcal{P}}{\partial \sigma} &= \left[\frac{\mathcal{P}^\varepsilon}{\alpha^{1-\varepsilon}(1-\varepsilon)} \right] \left[\frac{\partial i_D}{\partial \sigma} + (1-\varepsilon) \frac{(\sigma t)^{1-\varepsilon}}{\sigma} i_X + (\sigma t)^{1-\varepsilon} \frac{\partial i_X}{\partial \sigma} \right] > 0. \end{aligned}$$

The term $C_X = \int_0^{i_X} x(i) di$ represents a country's aggregate consumption of imported varieties of the differentiated good and I define $C_D = \int_0^{i_D} x(i) di$ as a country's aggregate consumption of the domestically produced varieties of the differentiated good.

For purposes of comparison, let the tariff level be identical to iceberg transport costs; i.e. $t = \sigma = \rho$. The differences in the welfare effect is:

$$\frac{\partial V}{\partial t} - \frac{\partial V}{\partial \sigma} = \left[\frac{(C_D + \sigma C_X) - \mu}{(\varepsilon - 1)} \right] \frac{(\sigma t)^{1-\varepsilon} f'(i_D)}{\rho \psi} - \frac{C_X}{(\varepsilon - 1)} < 0. \quad (34)$$

Therefore, excluding income effects from tariff or transport revenue, using the lessons learned from lowering iceberg transport costs underestimates the welfare benefits of trade liberalization from a reduction in tariffs. This suggests that, given the choice, it may be more welfare improving to focus efforts on tariff liberalization than lowering transport costs. Since like firms (domestic or exporting) have the same marginal cost and consequently the same price, the extensive margin is the driving force behind the change in the price index. Further, in

³⁰ Detailed derivations are available upon request.

this particular situation, iceberg transport costs are identical to per-unit costs since marginal costs are homogeneous and normalized to one. Therefore, in this setting, there are greater welfare gains from a reduction in an ad valorem tariff than a reduction in per-unit transport costs. Irarrazabal et al. (2010) find that the welfare gains from reducing per-unit frictions are higher than that of reducing iceberg frictions. Their model has heterogeneity across marginal costs which emphasizes within-market reallocation as an additional channel of gains from trade; this is obviously a different model. However, my model suggests that if ad valorem tariffs were used instead of iceberg transport costs, this gap in welfare gains would at the very least be dampened.

4 Conclusion

It is common in the recent trade literature to simply assume iceberg transport costs as a general proxy for many types of trade restrictions (in particular ad valorem tariffs). When perfect competition is assumed the two trade barriers are analogous. However, in the often used model of monopolistic competition, this is no longer the case. I have provided a simple model of trade with monopolistic competition and heterogeneous firms that illustrates how changes in iceberg transport costs affect profit differently than ad valorem tariffs. This, in turn, affects the elasticity of entry and exit differently. This elasticity of entry and exit is important as it affects the equilibrium number of varieties and the aggregate price index; both of which affect welfare. Furthermore, I have shown that although iceberg transport costs and ad valorem tariffs have an ambiguous effect on total variety, they do not necessarily have the same effect; i.e. it is possible for there to be an anti-variety effect associated with lower transport costs while there also being a pro-variety effect associated with lower tariffs. Finally, I have shown that using the lessons learned from lowering iceberg transport costs

underestimates the welfare benefits of trade liberalization from a reduction in tariffs. Thus, there are consequences in how one chooses to model trade restrictions. These consequences can be over(under)-emphasizing the effects of trade liberalization or a misspecified empirical equation. For instance, Cole (2010) illustrates using the Chaney (2008) framework that the elasticity of trade flows with respect to ad valorem tariffs is not a constant, like that of iceberg transport costs, but is a function of the elasticity of substitution. This has implications for how one would specify their estimating equation when using a gravity model.

References

1. Arkolakis, C. (2008). Market Penetration Costs and the New Consumers Margin in International Trade. NBER Working Paper No. 14214.
2. Baldwin, R. (1988). Hysteresis in Import Priced: The Beachhead Effect. *American Economic Review*, 78(4), 773-785.
3. Baldwin, R., and Forslid, R. (2010). Trade Liberalization with Heterogeneous Firms. *Review of Development Economics*, 14 (2), 161-176.
4. Becker, J. (2009). Taxation of Foreign Profits with Heterogeneous Multinational Firms. CESifo Working Paper Series No. 2899.
5. Broda, C., and Weinstein, D., (2006). Globalization and the Gains from Variety. *Quarterly Journal of Economics*, 121(2), 541-585.
6. Chaney, T. (2008). Distorted Gravity: The Intensive and Extensive Margins of International Trade. *American Economic Review*, 98(4), 1707-1721.
7. Chor, D. (2009). Subsidies for FDI: Implications from a Model with Heterogeneous Firms. *Journal of International Economics*, 78(1), 113-125.
8. Cole, M.A., Elliot, R., and Virakul, S. (2009). Firm Heterogeneity, Origin of Ownership and Export Participation. Discussion Papers 09-16, Department of Economics, University of Birmingham.
9. Cole, M.T. (2010). Distorted Trade Restrictions: A Comment on "Distorted Gravity". Working Paper No. 201019, University College Dublin.
10. Davies, R., and Eckel, C. (2007). Tax Competition for Heterogeneous Firms with Endogenous Entry: The Case of Heterogeneous Fixed Costs, IIS Discussion Paper No. 213.

-
11. Demidova, S., and Rodríguez-Clare, A. (2009). Trade Policy Under Firm-Level Heterogeneity in a Small Economy. *Journal of International Economics*, 78(1), 100-112.
 12. Eaton, J., Kortum, S., and Kramarz, F. (2008). An Anatomy of International Trade: Evidence from French Firms. NBER Working Paper No. 14610.
 13. Friedman, T. (2007). *The World is Flat: A Brief History of the Twenty-first Century*. New York: Douglas & McIntyre.
 14. Irarrazabal, A., Moxnes, A., and Opmolla, L. (2010). The Tip of the Iceberg: Modeling Trade Costs and implications for Intra-Industry Reallocation. CEPR Discussion Paper No. DP7685.
 15. Jean, S. (2002). International Trade and Firms' Heterogeneity under Monopolistic Competition. *Open Economies Review*, 13(3), 291-311.
 16. Jørgensen, J., and P. Schröder (2006). Tariffs and Firm-Level Heterogeneous Fixed Export Costs. *Contributions to Economic Analysis & Policy*, 5(1), 1-16.
 17. Jørgensen, J., and P. Schröder (2008). Fixed Export Cost Heterogeneity, Trade and Welfare. *European Economic Review*, 52(7), 1256-1274.
 18. Krugman, P. (1979). Increasing Returns, Monopolistic Competition, and International Trade. *Journal of International Economics*, 9(4), 469-479.
 19. Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade. *American Economic Review*, 70(5), 950-959.
 20. Lawless, M., and Whelan, K. (2008). Where Do Firms Export, How Much, and Why? Research Technical Paper 6/RT/08. Central Bank and Financial Services Authority of Ireland, Dublin.
 21. Melitz, M. (2003). The Impact of Trade on Intraindustry Reallocations and Aggregate Industry productivity. *Econometrica*, 71(6), 1695-1725.
 22. Melitz, M., and Ottaviano, G. (2008). Market Size, Trade, and Productivity. *Review of Economic Studies*, 75(1), 295-316.
 23. Schmitt, N., and Yu, Z. (2001). Economics of Scale and the Volume of Intra-industry Trade. *Economics Letters*, 74(1), 127-132.
 24. Yu, Z. (2002). Entrepreneurship and Intra-Industry Trade. *Weltwirtschaftliches Archiv/Review of World Economics*, 138(2), 277-290.